departure from solid/fluid equilibrium during diagenesis will increase with depth of burial if the pore fluid pressure is hydrostatic.

When mineral/fluid equilibrium is not reached, the mineral assemblage developed may be controlled by kinetic rather than thermodynamic factors. Solid phases not stable at the prevailing temperature and fluid pressure may form if high local solubilities create supersaturation in the bulk fluid with respect to many solids. The growth of minerals which decreases the total supersaturation rapidly is favored. Hence, fast-growing less-stable phases (for example, clays, zeolites, and aragonite) may form or persist at the expense of more stable but more slowly forming phases (i.e., illite, feldspars, and calcite). Consequently, the influence of both kinetic factors and bulk phase equilibrium should be considered in evaluating the genesis of mineral assemblages formed during diagenesis and burial metamorphism.

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Calcite Cement Recognition—Fact or Fantasy

The features characteristic of competitive growth such as plane intercrystalline boundaries, and increasing crystal size away from the substrate, together with the high frequency of enfacial junctions are regarded by others as intrinsic to cements and form the mainstay of its identification. The features of competitive growth are based on published crystal growth diagrams which are unrealistic because of gross oversimplification. The high frequency of enfacial junctions, claimed as the least unequivocal criterion for cement recognition, still requires explanation. The jerky growth required by cessation of one crystal's face while others grow against it seems unnatural.

Three new diagrams for specific calcite crystallographic forms ($(10\bar{1}1)$, $(40\bar{4}1)$, and $(01\bar{1}2)$ rhombohedra) are introduced. These show competitive or impingement aggregates developed through 3 or 4 maturation stages, and occuring in two basic types, one in which the crystals develop positive elongation, and the other in which negative elongation develops. These graphic models find their closest natural analog in parallel-side veins, but their properties can be applied to pore-fill cements which grew by seeding (without epitaxy) onto the pore walls.

The apparent enigma between the absence of enfacial junctions in the new diagrams and the high recorded frequency in natural aggregates is explained by reference to selected examples.

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Role of Multiple-Headed Submarine Canyons, River Mouth Migration, and Episodic Activity in Generation of Basin-Filling Turbidity Currents

The initiation mechanism and source of turbidite sediments to fill both recent and ancient offshore basins can be explained by examining nearshore submarine canyons like those off the Magdelline River, Columbia, and Rio Balsas, Mexico. To generate turbidity currents, large amounts of sediments of mixed grain size must first be stored as a stable deposit in the upper reaches of a canyon, then some mechanisms must create instability and set the entire deposit into motion. Canyons which head at deltas respond to the pulsating sources of sediment and the migration of the river mouth from one area to another. There is a flip-flop in the processes active in the canyon heads from one of erosion when the head is proximal and a large amount of coarse sediment enters directly into the canyon, to one of deposition of fine-grained sediment when the canyon head is distal and processes quiescent. During the distal stage, fine-grained cohesive sediments build up forming V-shaped profiles. The walls literally grow together. The migration of the river mouth back to the vicinity of a formerly quiescent distal canyon head will introduce coarse-grained sediments and reinitiate submarine erosion of the poorly consolidated canyon fill. Erosion forms steep unstable slopes and progressive slumping, creating the mechanism for generating a turbidity current with a large volume of poorly sorted driving sediment.

DILLON, WILLIAM P., U.S. Geol. Survey, Woods Hole, MA, CHARLES K. PAULL, Scripps Inst. Oceanography, La Jolla, CA, PAGE C. VALENTINE, U.S. Geol. Survey, Woods Hole, MA, et al

Blake Escarpment Carbonate Platform Edge: Conclusions Based on Observations and Sampling from Research Submersible

Three continuous transects of the Blake Escarpment, east of Florida, were made during 10 dives in the submersible Alvin at depths from 1,400 to 4,000 m. We observed and sampled outcrops of horizontal strata known, from multichannel profiles across the dive sites, to extend westward beneath the Blake Plateau carbonate platform. The northern end of the Blake Escarpment, at the salient of the Blake Spur, is a nearly vertical limestone cliff, which is pitted and commonly fluted by vertical borings, coated by ferromanganese oxide, and heavily encrusted by organisms. Presumably, the cliff face is maintained by bioerosion and corrosion, and debris is removed by the strong turbulent currents (2 kn). Average slopes were less steep at transects 130 and 200 km south of the Blake Spur, but vertical cliffs as much as 450 m high exist. Talus slopes are common, and the large blocks and landward dips of beds suggest collapse of fragments at least several hundred meters across. On the southern transect are broad slopes of rippled pteropod sand between near-vertical outcrops; a vertical 160-m cliff of massive limestone at the top of the escarpment and rudists in talus blocks suggest the presence of a Mesozoic reef. Preliminary analysis of calcarenous nannofossils shows rocks as old as Early Cretaceous; identification of older rocks is anticipated. Sedimentary structures and components indicate deposition in shallow water. Thousands of meters of subsidence and extensive erosional retreat were required to create the escarpment's present configuration.

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Field Study of Subaqueous Avalanching

Many submarine canyon walls consist of unconsolidated sand sitting at the angle of repose ($\sim 31°$). The sand walls commonly maintain this slope for many tens of meters before leveling out at the canyon bottom. Where such angle-of-repose sand slopes occur within scuba diving depth, they present an opportunity to study subaqueous grain flows in situ. Such a study has been conducted in the head of Carmel submarine canyon, Carmel Bay, California.

The object of the study was to determine the depositional pattern associated with subaqueous, gravity-driven grain flows. In particular, we attempted to determine whether the resulting deposits would exhibit inverse grading, as has been observed on the foresets of eolian dunes and in beach foreshore laminations. The experiments consisted of dumping dyed sand onto the slope, which generated a grain flow approximately 25 m long, and taking undisturbed cores both across and down the flow. The cores were dissected and the distribution of dyed grains determined.

Because the sand was divided into three size fractions that were each dyed a different color, grading and sorting patterns were readily discernible. In addition to inverse grading, we found sorting both down and across the flow, and the largest grains traveled the greatest distances. Because samples from natural, angle-to-repose sand slopes of Carmel Canyon show a downslope increase in grain size, we conclude that similar processes operate there. Once the slopes begin to level out, deposition of fine material from suspension becomes important and coarse material is no longer found in surficial samples.

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Ice Processes and Related Sedimentary Features in Tidal Flats, St. Lawrence Estuary, Quebec, Canada

Four to five months each year, ice is an active agent of erosion, transportation, sedimentation, and protection in tidal-flat environments along the St. Lawrence Estuary. Characteristic erosional and sedimentary features include chaotic microrelief up to 60 cm high, circular depressions 20 to 50 cm deep and up to a few meters in diameter, furrows 20 to 35 cm deep and up to 2 km long, ice-push ridges, deformational structures, ice-rafted boulders, and clumps of coarse and fine-grained material scattered throughout tidal flats. Every year, millions of tons of sediment of various texture are incorporated into ice, removed from the shore and nearshore zones, and transported over various distances ranging from a few decimenters to many kilometers. During the winter, the ice cover protects the tidal flats from wave and current erosion and allows deposition of 20 to 35 cm of soft mud under the ice sheet in the macrotidal zone. Modern cold region tidal flats show characteristic sedimentary features, structures, and sequences that can be useful in identifying ancient shelf sedimentary environments.

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Vertical Seismic Profiling—Processing and Analysis Case Study

Vertical seismic profiles require careful data collection and processing because of borehole noise and the necessity of separating upgoing and downgoing waves by apparent velocity. Major problems associated with these VSP data are tube wave noise and insufficient depth sampling.

Optimum processing of these VSP data permits analysis and tracking of the compressional wave field as it propagates at depth. The aliased tube wave noise is effectively attenuated by suitable f-k filtering at some expense of signal bandwidth. Subsequently, upgoing and downgoing waves are separated and enhanced, allowing identification of primary reflections, multiples, and borehole artifacts. VSP processing results show good correlation of nearby CDP data.

Limitations of VSP processing indicate the need for improved data-acquisition techniques. Increasing the source-borehole offset has been shown to attenuate borehole noise, but if interfering low-velocity signals persist, it is necessary to sample finely in depth to insure maximum signal bandwidth and high-frequency resolution after processing.

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Epigenetic Zoning in Surface and Near-Surface Rocks Resulting from Seepage-Induced Redox Gradients, Velma Oil Field, Oklahoma

Surface and near-surface Permian sandstone has been drastically altered over the productive part of the structurally complex Velma oil field as a consequence of petroleum microseepage. Buried Permian sandstone along the northwest-southeast-trending anticline is cemented with abundant pyrite and isotopically anomalous ferroan calcite and ferroan dolomite. At the surface along the anticlinal crest, iron sulfide is scarce; carbonate-cemented sandstone is overlain by sandstone that is massively impregnated by hematite cement. Permian sandstone is normally reddish brown throughout southern Oklahoma, but along the anticlinal flanks it has been bleached yellow and white owing to iron loss; some units contain abundant solid bitumen.

The mineralogy in the vertical section over the anticline follows the calculated stability relations for iron oxides, sulfides, and carbonate along a gradient from strongly reducing conditions at depth to oxidizing conditions at the surface. Reducing conditions were readily provided by seeping hydrocarbons from subsurface reservoirs of this multizone giant field. Production depths range from 120 to 2,180 m. The principal evidence that these are seepage-induced alterations is provided by reports of oil seeps in the early literature, by zones of solid bitumen cements, and by δC^{13} PDB values for carbonate cements that range from -7.8 to -36.7 ppt.

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Biogenetic Control of Gases in Marine Sediments of Santa Barbara Basin, California

The primary controls on the quantity of methane found in sediments are the rates of production and the rates of diffusion. In Santa Barbara basin sediments, the diffusion rate of methane is found to be very slow compared to the rate of bacterial production. The production rate correlates with the amount of organic matter in the sediment. Thus, the quantity of methane at any depth in the sediment is a function of the amount of marine organic matter initially trapped in the sediment.

Sediment cores show the concentration of SO_4 decreasing from 27.6 mM at the surface to zero below 2 m. The methane concentration is < 0.3 mM in the upper 2 m, increases to 12.3 mM at 3.8 m, then decreases and fluctuates. The production rate of HCO_3 decreases from 1.5×10^{-4} mmol/cu cm/year at the surface to less than 10^{-7} mmol/cu cm/year at 9 m. The production rate of HCO_3 fluctuates in direct correlation with organic carbon content. Methane production decreases in a similar manner. The $\delta^{13}C$ distribution of biogenic methane variesfrom -92.8 to -23.6 ppt. Heavy biogenic methane occurs in the upper sulfate-reducing zone and may result from the preferential anaerobic oxidation of light methane by sulfate-reducing bacteria. The diffusive flux of methane into the sulfate-reducing zone is between 8.6×10^{-5} mmol/sq